

Synthesis and Characterization of Li substituted Ni-CoFe₂O₄ Nanopowder by Using Sol-Gel Method

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Abstract: Lithium substitute Nickel – Cobalt nanoferrite are Co-Ni Li_(x)Fe_{2-x}O₄ (where x=0.05, 0.075, 0.1) Nano ferrite powders were synthesized by sol-gel method it is simple and cost effective at low temperatures. Nickel ferrite is a typical soft and ferromagnetic material with a completely inverse spinel structure, has a large number of applications. The present work is to study structural and magnetic properties of the synthesized samples. The role of Li (Lithium) substituted Ni (Nickel)-Co (cobalt) shows the formation of crystal phase, which was identified by X-ray diffraction method. The lattice constant increases with the increasing in Li contain. The prepared samples were characterized by X-ray diffraction and hysteresis loop. From XRD characterization the structure of the material is found to be spinel ferrite. The average particle size is in range of 52 to 64 nm. The magnetic properties were studied by hysteresis loop.

INTRODUCTION

Recent studies have shown that the physical properties of nanoparticles are enhanced significantly by various processing technique and with different composition. A number of chemical routes have been used for the synthesis of ferrite nanoparticles. These methods includes sol-gel [1], micro emulsion [2], chemical co-precipitation [3] etc. From crystal structure point of view, ferrites are generally divided into two groups: cubic or spinel ferrites and hexagonal or hexa ferrites [4,5]. Sol-gel method is used to obtain improved properties, more homogeneity and narrow particle distribution, thereby influencing structural [6], electrical and magnetic properties of ferrite [7,8]. It is interesting and important to develop techniques by which the size and structure of the particles can be well controlled. This material is used in the wide range of applications in gas sensing⁴, catalytic applications, Li ion batteries [9] high density magneto-optic recording devices, color imaging, bioprocessing, magnetic refrigeration and ferrofluids [6]. In the present work we have successfully synthesized and studied the effect of Li on the structural properties of Co NiFe₂O₄ samples. CoNi_(1-x)Li_(x)Fe₂O₄ Nanoparticles were successfully prepared by Sol-

gel auto-combustion method. Ni²⁺ substituted Mg-Zn spinel ferrite has been synthesized by sol-gel method and studied phase crystal structure and morphology (D. H. Bobade et al, 2012) [10] Cu²⁺ ion concentration in Ni-Zn spinel ferrite by combustion method has been investigated single phase cubic structure and surface morphology. (V. V. Awat et al, 2013) [11].

EXPERIMENTAL DETAILS

Synthesis of cobalt ferrite nano particles

The high purity AR grade ferric nitrate (Fe₂(NO₃)₂·9H₂O), Lithium nitrate (Li(NO₃)₂·6H₂O), Cobalt nitrate (Co(NO₃)₂·6H₂O), citric acid (C₆H₈O₇), Nickel nitrate (Ni(NO₃)₂·6H₂O) ammonium hydroxide solution (NH₄OH) were used to prepare Co-NiLi_(x)Fe_{2-x}O₄ (x=0.05, 0.075, 0.01) nanoparticles by sol-gel auto combustion synthesis technique. In this chemical process Citric acid was used as a Fuel. These nitrates and citric acid were weighed accurately to have proper stoichiometric proportion required in the final product. The mixed solutions of all the chemicals were stirred until the homogeneous solution is obtained. During the stirring process ammonium hydroxide solution was

added drop by drop to obtain pH of 7. The mixed solution was simultaneously stirred and heated for 3 to 4 hrs to form a gel after that auto-combustion takes place. The prepared powder was sintered at 560 °C for 4 hours, and the crystalline Nano powder of sample was obtained.

RESULTS AND DISCUSSION

XRD Analysis

XRD pattern is used to estimate the average size of very small crystallites, from the measured width of the peaks in the different pattern.

The interplane distance were calculated by using bragg’s equation from the relation

$$n\lambda = 2d \sin \theta \text{ _____ [1]}$$

The lattice parameter ‘a’ was calculated using following relation

$$a = d\sqrt{h^2 + k^2 + l^2} \text{ _____ [2]}$$

Where (hkl) is the miller indices, λ is the wavelength of X-ray radiation and θ is the Bragg angle. The results of interplane distance and lattice parameter are shown in table 1.

The particle size were calculated using Scherrer’s formula

$$t = \frac{0.9\lambda}{\beta \cos \theta} \text{ _____ [3]}$$

Where, “t” is the particle size, and β is the FWHM (full width half maxima) of the peak θ.

| Composition | Average particle size “t” (nm) | Interplanar distance “d” (nm) | Lattice constant “a” (Å) |
|--|--------------------------------|-------------------------------|--------------------------|
| CoNiLi _(0.05) Fe _{1.95} O ₄ | 64 | 2.0312 | 8.3768 |
| CoNiLi _(0.075) Fe _{1.925} O ₄ | 60 | 2.1641 | 8.3858 |
| CoNiLi _(0.1) Fe _{1.9} O ₄ | 52 | 2.1643 | 8.3978 |

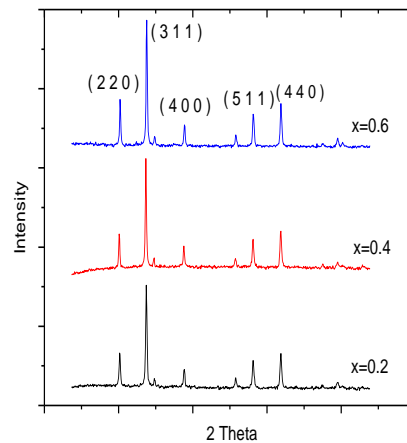
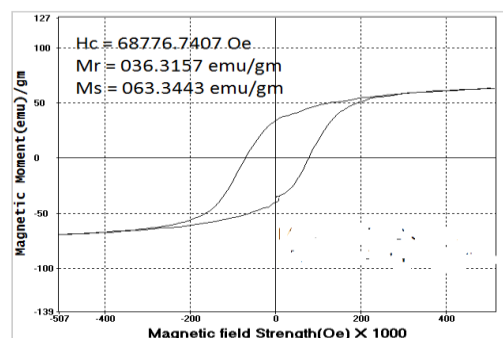


Fig: XRD of Zn_{1-x}Co_xFe₂O₄

TABLE 1: Structural parameters of cobalt ferrite nanoparticles



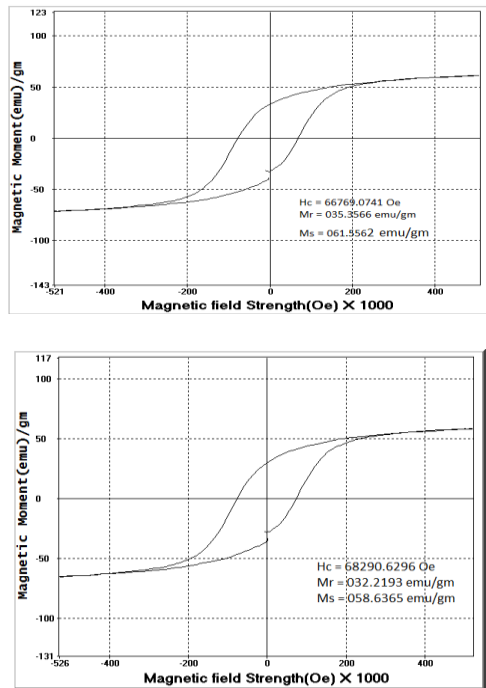


Fig: VSM of $\text{CoNi}_{(1-x)}\text{Li}_{(x)}\text{Fe}_2\text{O}_4$

CONCLUSIONS

$\text{Co-NiLi}_{(x)}\text{Fe}_{2-x}\text{O}_4$ Nano sized powder synthesized successfully by sol gel- auto combustion method. From XRD calculation it is conclude that average grain size goes on decreasing as concentration increases. Synthesized material is in nanostructure range and spinel ferrite form, the magnetic properties were studied by hysteresis loop and it is found that the magnetic saturation goes on decreasing as percentage of Li goes on increasing.

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